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THE WAHOO *ACANTHOCYBIUM SOLANDRI* (CUVIER, 1832) FISHERY IN EL HIERRO ISLAND (CANARY ISLANDS, SPAIN) AND BIOLOGY IN THE EAST ATLANTIC OCEAN

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SUMMARY

Data on the fishing activity of the island of El Hierro are presented. The wahoo download data is compared in El Hierro and in the rest of the archipelago. The relative importance of the different resources exploited on the island of El Hierro is analyzed. Landing data by quarter are presented throughout the 2007-2018 period. The seasonality of landing is analyzed. The size distribution of the artisanal fishery landing from the BB of the Canary Islands is presented and compared with the distribution of wahoo by-catch of Purse Seiner fishery. A new length-weight relationship for this species from the eastern central Atlantic is presented.

RÉSUMÉ

Des données sur l'activité de pêche sur l'île d'El Hierro sont présentées. Nous comparons les données de débarquement du thazard-bâtard à El Hierro et dans le reste de l'archipel. L'importance relative des différentes ressources exploitées sur l'île d'El Hierro est analysée. Les données de débarquement sont présentées par trimestre pour la période 2007-2018. Le caractère saisonnier des débarquements de thazard-bâtard à El Hierro est analysé. La répartition par taille des débarquements de la pêche artisanale de canneurs des îles Canaries est présentée et comparée à la répartition des prises accessoires de la pêche industrielle des senneurs tropicaux de l'Atlantique. Une nouvelle équation du rapport taille/poids est présentée pour cette espèce de l'Atlantique Centre-Est.

RESUMEN

Se presentan datos de la actividad pesquera de la isla de El Hierro. Se comparan los datos de descarga de wahoo en El Hierro y en el resto del archipiélago. Se analizan la importancia relativa de los diferentes recursos explotados en la isla de El Hierro. Se presentan datos de descargas por trimestre a lo largo del período 2007-2018. Se analiza la estacionalidad de sus descargas de wahoo en El Hierro. Se presenta la distribución de tallas de las descargas de la pesca artesanal de BB de Canarias y se compara con la distribución de by-catch de la pescar industrial de cerqueros tropicales del Atlántico .Se presenta una nueva ecuación de relación talla-peso para esta especie del Atlántico centro oriental.

KEYWORDS

Fishing activity, catch composition, catch statistics, artisanal fisheries, length distribution, length-weight relationships

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1. Introduction

In 2019, even in Canary Islands, ancestral fisheries deeply rooted in the fishing traditions are developed. The artisanal fleet segment typical from the Canary Islands compound by small, fast and light vessels that carry out daily fishing trips. The main characteristics of these fisheries is the daily nature of their trips, exploits a wide variety of resources "multispecies fishing" through the use of a wide variety of fishing gears and has a very marked seasonal character throughout the year. The fishing resources that are exploited in the Canary Islands have two slightly different natures: 1º "demersal fishing resources": constituted by species that develop their entire life cycle in the environment of the islands and 2º "migratory fishing resources": constituted by those oceanic resources that visit the islands in certain months throughout the year. The Canary Islands archipelago and its surrounding waters are part of the Canary region, which is located on the eastern edge of the subtropical gyre of the North Atlantic and is bathed by the Canary current fed by the Azores current (Fiekas*et al.*, 1992). The Canary Islands act as a barrier to the Canary Current and the trade winds which introduce strong variability in the atmospheric and oceanic flows, giving rise to mesoscale oceanographic processes, such as eddies and warm wakes, to leeward of the islands (Mittelstaedt, 1991, Hernández-Guerra *et al.*, 1993; Arístegui*et al.*, 1997; Barton *et al.*, 1998).On a biological level, these phenomena entail an increase in planktonic production. Likewise, the water masses from the Northwest African upwelling displaced offshore towards the Canary Islands by the Ekman transport and the upwelling filaments may reach the eastern part of the Canary region. Consequently, this region straddles the transition between the cool, nutrient-rich waters of the coastal upwelling regime and the warmer, oligotrophic waters of the open ocean (Barton *et al.*, 1998).These ecological differences between islands, explain or justify, the great differences existing at the level of catches between islands.

At present, the migratory oceanic fishing resources that reach the Canary Islands, due to their volume of catches and high economic value, constitute the main resources exploited by artisanal fisheries in the Canary Islands. In the Canary Islands, 5 species of tuna, 3 tropical species (*Thunnus obesus*, *Thunnus albacares* and *Katsuwonus pelamis*) and 2 subtropical species (Thunnus alalunga and Thunnus thynnus) are captured, which find in the Canary waters an ideal food source in their oceanic migratory routes.

The wahoo (*Acanthocybium solandri*) catches, are also important, especially for some of the western most islands of the Canary Islands. Some time, the capture of this small tuna, reach more than half of the total catches of the El Hierro. The western waters of the Canary Islands, have a more oceanic character and with the warmer temperatures, which favors the presence of wahoo population, mainly tropical in subtropical latitudes. Wahoo fishing in El Hierro occurs throughout the year, but it is during the winter months when catches are most important.

2. Material and methods

Sources of information were as follows:

ICCAT data: Historical official data from Spain Fisheries Office sent to ICCAT. Time series from 1985 to 2006.

Landings and value: Filtered by us information from First Sale Spots Network (Canary Islands and Spain Fisheries Offices), time series from 2007 to 2018.

Biological data: Size and weight data of wahoo was obtained from the National Spanish Program Observer onboard Spanish Purse Seiner fleet than operated in the East Atlantic Ocean from 2008 to 2018. Size and weight data of wahoo was obtained from our network sampling at the Canary port from 1985 to 2018 and from the Small Tuna Research Program. ICCAT CIRCULAR # 2478/2018 developed in La Restinga (El Hierro) in 2018.

Fleet structure: Official data from Spain Fisheries Office.Time series from 2007 to 2018.

Statistical analyses (non-parametric Kruskal-wallis test) were made to evaluate the differences between groups by SPSS software and R-Studio with packages (FSA v0.8.1.7, car; dplyr; magrittr; readxl in J.De La Hoz Maestre 2018) were made to obtain the relationship length and weight of wahoo data.

3. Results

Fleet

The total number of vessels in Canary Islands has continuously decreased with time, being during the 2007-2018 period between 900 and 550 units respectively. This amount holds steady after 2012 for the rest of the period in around 600 vessels. El Hierro, smallest island of archipelago, has around 30 artisanal vessels in active fishing. This number of vessels per length class (m), the case more abundant length classes are the shorter ones, (6-<8, 8-<10 and 10-<12 m). The bigger vessels' >12 m, with around 4 vessels are less abundant.

The fishing activity in the vicinity of El Hierro is carried out with a radius of about 10 nautical miles, operating with hand-line, trolling with plastic lures, different poles and hooks are used. Trolling and "Vara de Peto" (big hook-arpon hand operated) are the main gears used to fish wahoo in El Hierro. All fishing gears working with lines and hooks are included in this gear type. Lines can be fibber, synthetic or metallic made. Hand line is a type of trolling gear, constituted by a synthetic line with plastic lures at the end. The "Vara de Peto" or hook-arpon is made with a big hook (25 cm diameter) tied on the tip of a big pole and wood lures with the same shape are used to attract the target specie to the boat. In the best moment the "Vara de Peto" At the best moment, the stick rod is thrown from the boat, in the same way as the old whale hunts (**Figure 1 and 2**).

Landing

The yearly landing of this species in the Canary Islands from 1985 to 2018 is presented (**Table 1A, 1B**). The first years of the historical series of captures, before 2007, the data must be considered as incomplete (**Table 1A**). In 2007, a new system for collecting fishing data "First Sale Spots Network" started and the coverage of catch records increased to more than 95% of the Canary Islands ports. There is a progressive increase in the volume of catches from 1985 to 2007, this progressive increase of landing wahoo is explained as a consequence of the implementation of this new system (**Figure 2**). After 2007, the landing show a stability around 50 tons on average per year. In 2011 the catches reached more than 70 tons and the annual maximum with almost 80 tons in 2009 (**Table 1B** and **Figure 2**).

In El Hierro Island, as in the rest of the archipelago, seven different marine resources are mainly exploited. The landing from the main marine resources in the last 10 years is presented as percentages of the total catches (**Figure 3**). The main resource exploited on the island, named "Demersal fish", is formed by more 60 different demersal species of fish fished on the scarce insular platform and slope. This commercial category, ranged from about 46 t for the year 2011 representing 40% of the total landing, up to 84 t of the year 2008 with more than 35% of the total landing and reaching to average capture about 66 t per year (**Figure 3**).

The fishing of the large tunas that visit the archipelago in different periods is very seasonal and the main target species are *Katsuwonus pelamis*, *Thunus obesus*, *Thunnus alalunga*, *Thunnus thynnus* and *Thunnus albacares*, constitute the second resource in importance. The catches ranged from 15 t in 2008, representing around 8% of the total to more than 337 t in 2016, where they came to represent more than 75% of the total fished on the island (**Figure 3**).

And finally the third important resource, for this island are the wahoo catches, reaching around 24 t in 2014 to more than 50 t in 2018. The volume of landing of wahoo, represent from a minimum of 8% to a maximum of 36% of the total catches landing in El Hierro (**Figure 3**).

In **figure 4**, the historic comparative annual of wahoo landing of El Hierro and the rest of archipelago is presented. It is observed that the catches of wahooo of El Hierro represent from 38.6% to more than 75% of the total landing in the whole archipelago. In 2012, there are no catches as a consequence of the submarine eruption that occurred in that year in the island. In the last four years, the wahoo catches of this small island represent around 75% of the total captured in the whole archipelago (**Figure 4**).

The catches of wahoo, on the island of El Hierro, are carried out throughout the year. But catches of this species also have seasonal rhythms. In the figure 5, the catches made by quarters over the period 2007-2018 is presented. It is observed as the fourth quarter of each year, represents the largest volume of annual discharges (**Figure 5**).

In **Figure 6**, average of landing in each month of the year and their standard deviations is presented. It is observed how the winter months tend to be those with the highest volume of landing, in addition to having greater oscillations in their catches. The monthly distribution of wahoo landing showed the highest values between the months of October and January, showing significant differences between months (K-W, gl=11. sig.asintot. < 0.0001) (**Figure 6).**

Size, weight and length distribution

In **table 2**, the descriptive statistics of the length frequency obtained in the different scientific programs and projects carried out in recent years is presented. In the figure 7, size class frequency distribution of wahoo catches made by the artisanal fishing boats (BB) of El Hierro and, as a comparison, the size class frequency distribution of wahoo bycatch in the Spanish purse seiner fishery (PS) is presented. The size class range of catches are between 100 cm the smaller to 180 cm the larger one, and the artisanal fishery show two principal modal sizes class 130-135 cm and 135-140 cm very often, representing around 20% of the sizes class in catches. On the other hand the PS fishery shows two principal size classes of bycatch wahoo around 30-25 cm and 155-160 cm long. This fishery showed a unimodal size class structure around 110 cm long for the wahoo bycatches (**Table 2** and **Figure 7**).

In **table 3**, a comparative table of the different length-weight relationships of the species according to the geographical area are fished (west and east of the Atlantic Ocean) is presented, showing the existing variations among the set of localities. For the length-weight relationships, this is evidenced by the similar estimated weights for a 110 cm fish (**Table 3).** In **Figure 8,** the new relationship length-whole weight for wahoo from the East Central Atlantic, the best fix in green line and confidence interval for 95%, is presented. The wahoo growth follows an negative allometric pattern with value (b<3), Ho: $\beta=3$ (T=-11.27, d=1630, p-valor= $1.9070e^{-28}$), growth in length is faster than growth in weight.

4. Discussion

The fishing activity developed around El Hierro Islands by bait boat artisanal started in 1920, when some boats based in La Gomera Island began to fish tunas and tuna like-fishes using hand-line, poles and "Vara de Peto" as main fishing gears and use small pelagic fish as bait (Cabrera, 1973). Presently, around thirty bait boat artisanal vessels based in El Hierro Islands.

In the Canary Islands, the fishing activity is multi-species and multi-arts. Various marine resources are exploited according to their seasonal rhythms. On the island of El Hierro, when catches of tuna are scarce, the catches of "demersal fish" and "Wahoo" compensate for the low volumes of captures of oceanic resources. This behavior is clearly observed in the 2007-2013 period, where tunas accounted for around 10-20% of the total catches, while "demersal fish" catches reached 40% of the total in this period. The "wahoo" catches also represented high percentages catches between 15-35% of the total captured on the island. However, when the volume of tuna catch is high, as the period 2014-2018, it`s to reach between 40-70% of the total captured on the island, the volume of catches of "demersal fish" and "wahoo" " are no more than 30% or 15% respectively. The variation of catches of wahoo and demersal fish are not consequence of seasonal changes in their biomass, the variation catches of wahoo and demersal fish are not consequence of seasonal changes in their biomass, they are explained as a consequence of the fishing behavior of the fishermen, because the fishing strategy change with the presence or absence of tuna fish in their fishing zone. The tuna fish, generally, have a higher commercial value than the others.

These high percentages of catches in El Hierro Island are similar to other important places where wahoo are caught, as in the Brazilian archipelago of Saint Peter and Saint Pablo, where the catch of wahoo reaches a level higher than 11% of the total catches (Oliveira *et al.* 1997).

The presence of Wahoo populations on the island is usually constant throughout the year, which represents a regular volume of catches of around 35 tons per year, this result is according with García 1973 and Mena *et al.* 1993. This volume of captures converts this oceanic resource into a safe value that compensates the deficiencies or decreases of catches the other resources exploited. According García 1973 and Mena *et al.* 1993, the wahoo catches are higher during spring and autumn (García 1973; Mena *et al.* 1993). However our results show higher catches during the four or first quarter of the year. The winter months October to January were must important to landing wahoo in all data period from 2007 to 2018. Viana *et al.* 2008 reported higher catches of wahoo in winter months too. It is necessary future seasonal studies to check better the breeding season of this species.

In St. Lucia from artisanal fishery landing show a size-range of 32.5 cm-212.5 cm and unimodal size structure around 77.5 cm-97.5 cm FL (Neilson *et al.* 1999). In North Carolina, Hogarth (1976) reported that wahoo landed by recreational fishery ranged in size from 76 cm to 205 cm TL. Wahoo landed in Bermuda had a unimodal size structure with size range of 72 cm to 180 cm and a modal size of 118 cm FL (Luckhurst and Trott 2000). Length-frequency data our study show a short size-range of wahoo between 100 cm to 180 cm FL and a width unimodal size structure around 130-140 cm FL. The presence of small and large sizes in Caribbean islands such as St. Lucia (Neilson *et al.* 1999) or Bermuda (Luckhurst and Trott 2000) and absence of small sizes in artisanal catches of El Hierro suggests that the breeding areas are far away of this island. Equatorial zones or in Caribbean waters would be the priority areas for spawning.

For wahoo, estimates by Brown-Peterson *et al.* (2000) indicated that males and females reach 100 % maturity at 105 cm FL (approximately 2 years old). Both males and females from North Carolina reach sexual maturity during their first year of life, at around 86 cm TL for males and 101 cm TL for females (Hogarth 1976). According this information, the population exploited in El Hierro is clearly of the adult fraction. The immature and sub-mature fraction of the species is captured in tropical waters, as confirmed by the data obtained in the National Spanish PS Observer program.

These results confirm the hypothesis already mentioned by other authors who affirm that wahoo, is born in tropical waters and disperses towards subtropical latitudes to feed and grow.

The result of our growth estimates of wahoo, shows to be negative allometric ($b < 3$), which means that large specimens are longer than small specimens (Froese 2006).

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Tabla 1 A. Total landing of Wahoo (*A. solandri*) by year in Canary Islands from 985 to 2018.

Years	Total Catch Wahoo (t)
1985	4
1986	9
1987	9
1988	32
1989	18
1990	23
1991	28
1992	32
1993	22
1994	20
1995	15
1996	25
1997	25
1998	29
1999	28
2000	32
2001	38
2002	46
2003	48
2004	47
2005	21,4
2006	55
2007	59,5
2008	42,3
2009	79,5
2010	58,1
2011	75,9
2012	36,2
2013	54,6
2014	39,0
2015	40,4
2016	53,0
2017	44,6
2018	73,4

Tabla 1B. Total landing of Wahoo (*A. solandri*) by ports in Canary Islands from 2007 to 2018.

Landing Port	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Arguineguín (Gran Canaria)			19	21	395		14		29		20	
San Cristóbal (Gran Canaria)	89	73	71							3		
Taliarte (Gran Canaria)				39	210	209	52	20				21
Total Gran Canaria	**89**	**73**	**90**	**59**	**604**	**209**	**66**	**20**	**29**	**3**	**20**	**21**
Playa Blanca (Lanzarote)				80		68		20	35			108
Arrecife (Lanzarote)				12		20	40	27		80		
Caleta del Sebo (Lanzarote)		385		99	252			40				
Total Lanzarote	**0**	**385**	**0**	**191**	**252**	**88**	**40**	**87**	**35**	**80**	**0**	**108**
Gran Tarajal (Fuerteventura)				40	69	4574	26		72		44	
Morro Jable (Fuerteventura)		108	2795	2107	3401	8890	65	288	297	1043	246	53
Total Fuerteventura	**0**	**108**	**2795**	**2147**	**3470**	**13464**	**91**	**288**	**369**	**1043**	**290**	**53**
Valle Gran Rey (La Gomera)		150	1209	528	203	105	1016	701	337	457	386	
San Sebastián (La Gomera)												420
Total La Gomera	**0**	**150**	**1209**	**528**	**203**	**105**	**1016**	**701**	**337**	**457**	**386**	**420**
Los Abrigos (Tenerife)							20	191	25	166	294	446
Los Cristianos (Tenerife)			393	414	185	18						
Guía Isora (Tenerife)			26	55,5	81	907	346					
Garachico (Tenerife)							11			18,5	20	17
Candelaria (Tenerife)										11	411	239
Playa de San Juan (Tenerife)								194	759	1241	1496	1748
Puerto de La Cruz (Tenerife)			20		20							
San Andrés (Tenerife)								23				89
Tajao (Tenerife)			232	183	484	170	73	46	47	106	164	378
Santa Cruz de Tenerife	28275	14196	26885	17494	23947	9753	13507	9634	4823	6237	2581	3383
Total Tenerife	**28275**	**14196**	**27557**	**18146**	**24717**	**10848**	**13956**	**10088**	**5654**	**7779**	**4964**	**6300**
Santa Cruz de La Palma		2545	6643	2832	10246	5813	3257	3585	2047	2477	1382	1207
Tazacorte (La Palma)	3240	2817	8256	3081	7092	5678	5041	6572	2452	2684	3992	8981
Total La Palma	**3240**	**5362**	**14899**	**5914**	**17339**	**11491**	**8298**	**10158**	**4499**	**5160**	**5374**	**10188**
La Estaca (El Hierro)										2548	4691,5	910
La Restinga (El Hierro)	27852	21979	32936	31105	29322		31167	17641	29434	35947	28867	55415
Total El Hierro	**27852**	**21979**	**32936**	**31105**	**29322**	*******	**31167**	**17641**	**29434**	**38495**	**33558**	**56325**
Total Canary Islands(Kg)	**59455**	**42253**	**79485**	**58089**	**75888**	**36205**	**54634**	**38982**	**40357**	**53017**	**44593**	**73415**

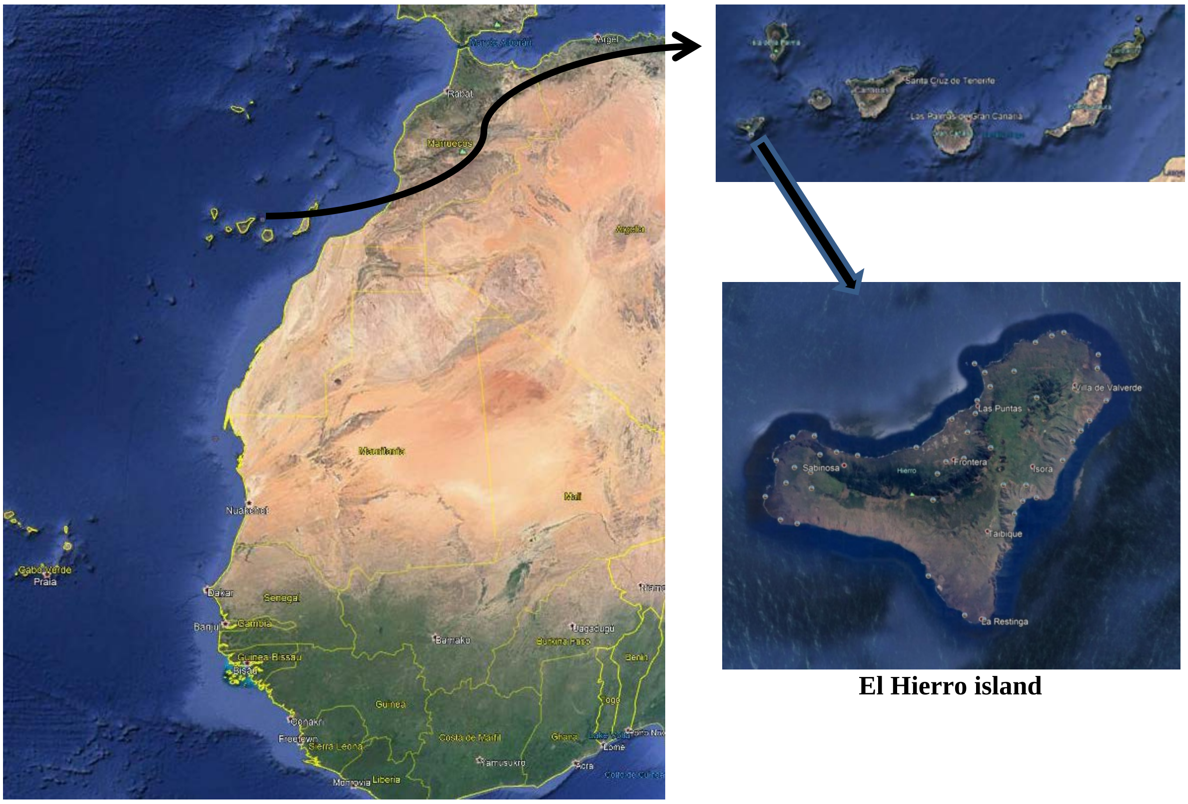
*** Volcanic submarine process affected all marine ecosystem around El Hierro Island and any fishery activity developed in 2012.

Table 2. Statistic descriptive of the length of Wahoo (*A. solandri*) measures by programs and proyect.

Statistic descriptive	BB- El Hierro . IEO data and Small Tuna Research Program. ICCAT CIRCULAR # 2478/2018	PS-SpanishObsProgram 2008-2018.
Media	136,4	105,2
Mediane	136,5	107,0
Moda	130-134.9	110-114.9
Desv. típ.	8,9	13,7
Varianza	79,7	186,4
Mín.	110	30,0
Máx.	180	155,0
N	536	1632

Tabla 3. Length and weight relationships for wahoo from the western central Atlantic region, Canary Islands and this study.

Area	Location	Relationship	Sex	Sample size (n)	Equation	Est. Kg at 110 cm	Reference
Southeastern Caribbean	Trinidad&Tobago	Length-whole weight (Wt in Kg, L in cm)	All	391	$Wt=8.9x10^{-8}xFL^{3.862}$	6.8	Kishore and Chin 2001
Northern Caribbean	Bahamas	Length-whole weight (Wt in Kg, L in cm)	All	91	$Wt=2.037x10^{-6}xFL^{3.201}$	7.0	Hogarth 1976
Eastern USA	Florida	Length-whole weight (Wt in Kg, L in cm)	All	?	$Wt=1.544x10^{-6}xFL^{3.294}$	8.2	Beardsley and Richards 1970
	North Carolina	Length-whole weight (Wt in Kg, L in cm)	All	795	$Wt=1.845x10^{-6}xFL^{3.218}$	6.87	Hogarth 1976
	Maryland	Length-whole weight (Wt in Kg, L in cm)	All	32	$Wt=1.517x10^{-6}xFL^{3.247}$	6.4	Hogarth 1976
Atlántic	Bermuda	Length-whole weight (Wt in Kg, L in cm)	All	72	$Wt=0.446x10^{-6}xFL^{3.502}$	6.3	Hogarth 1976
Atlántic	Canary Islands	Length-whole weight (Wt in Kg, L in cm)	All	332	$Wt=2.749x10^{-6}xFL^{2.72252}$	9.9	Santana *et al.* 1992
This Study	East Atlantic	Length-whole weight (Wt in Kg, L in cm)	All	1440	$Wt=2.03141x10^{-6}xFL^{2.71835}$	7.1	2019



El Hierro island

Figure 1. Geographical location of the Archipelago of Canary Islands (Spain) and El Hierro Island.

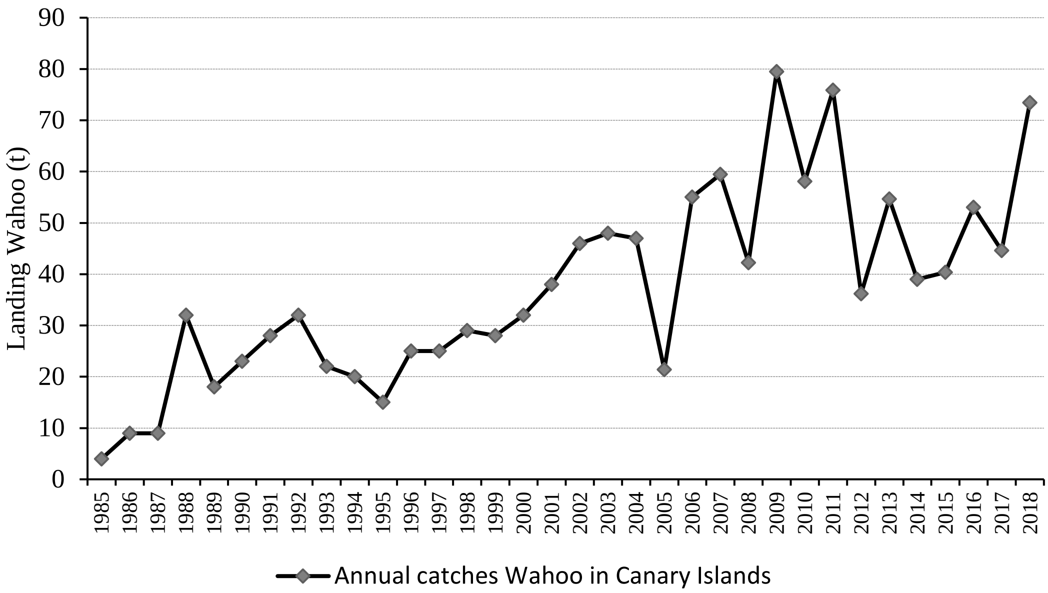


Figure 2. Yearly landing of wahoo caught in the Canary Islands.

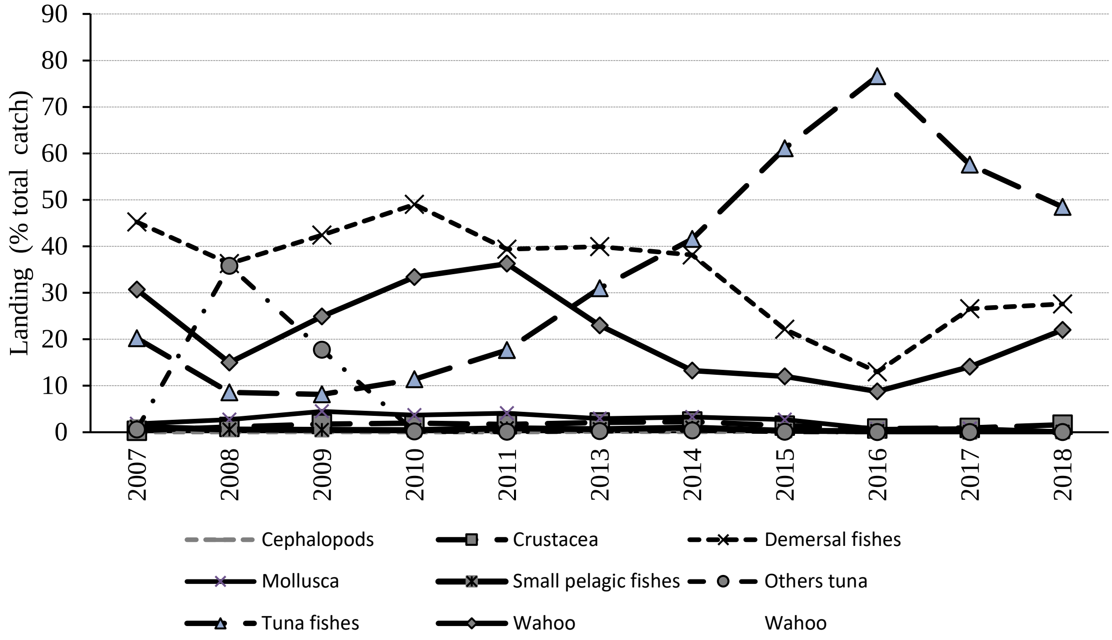


Figure 3. Landing exploited marine resources, in percentage per year, of El Hierro from 2007 to 2018.

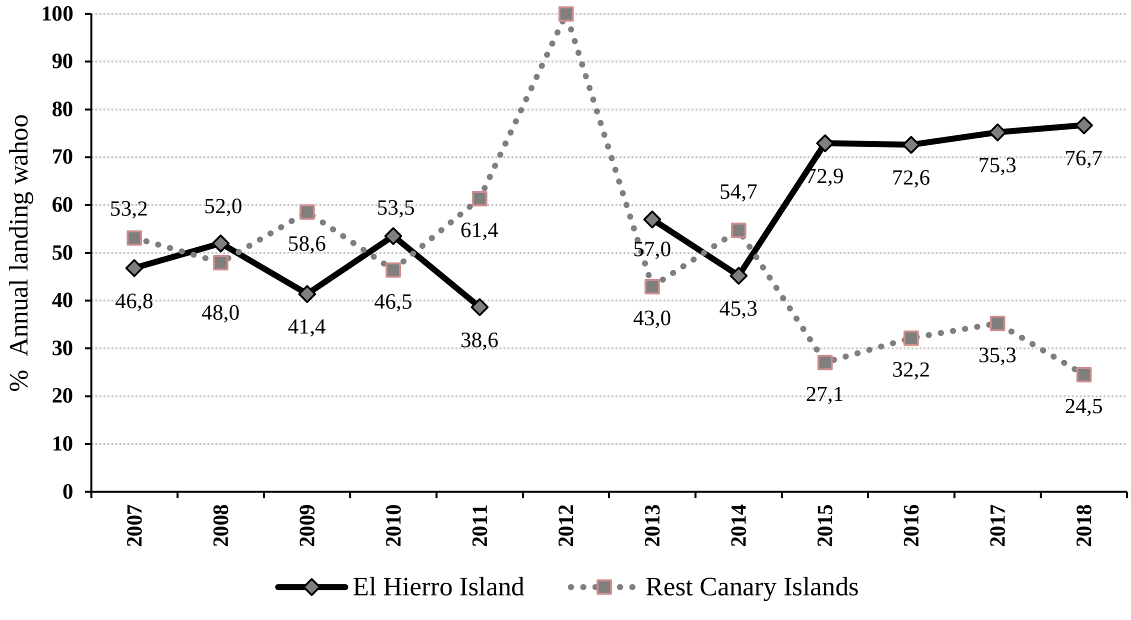


Figure 4. Relative percentage of annual landing of wahoo, El Hierro and rest of the Canary Islands,

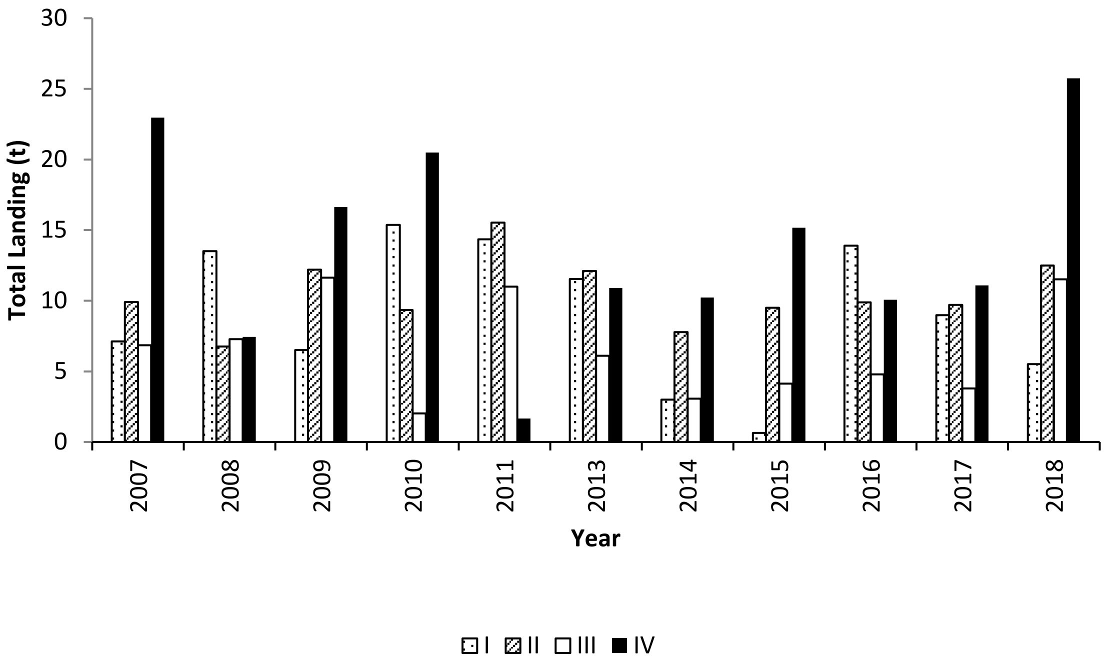


Figure 5. Quarterly distribution, per year, of landing of wahoo caught in El Hierro from 2007 to 2018.

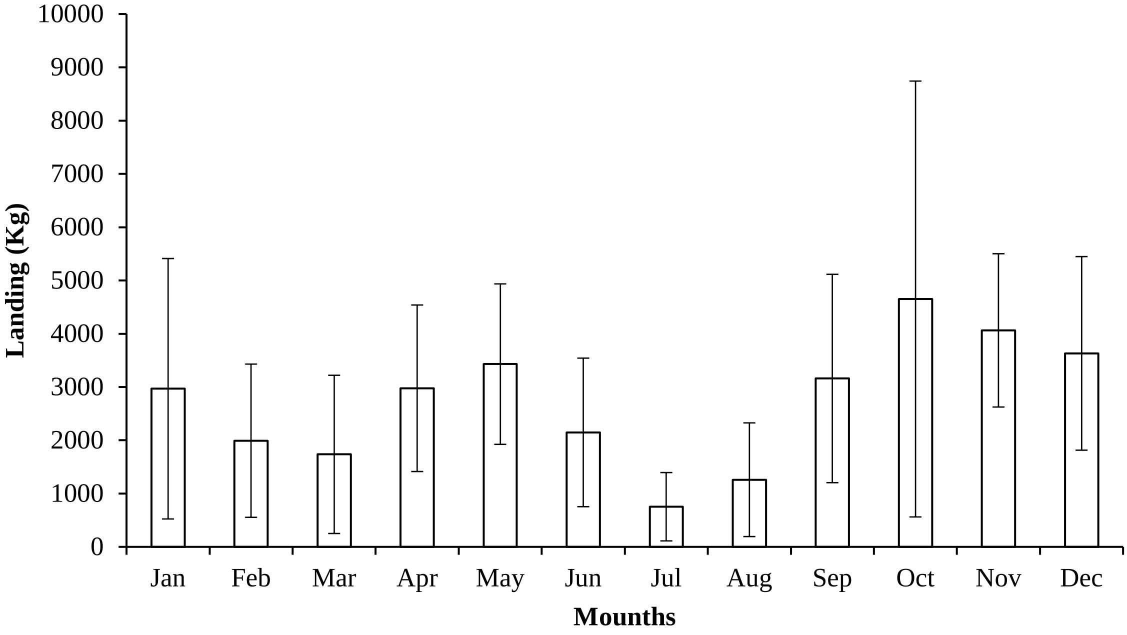


Figure 6. Monthly average distribution of landing of wahoo caught of El Hierro from 2007 to 2018 (vertical bars indicate standard deviation).

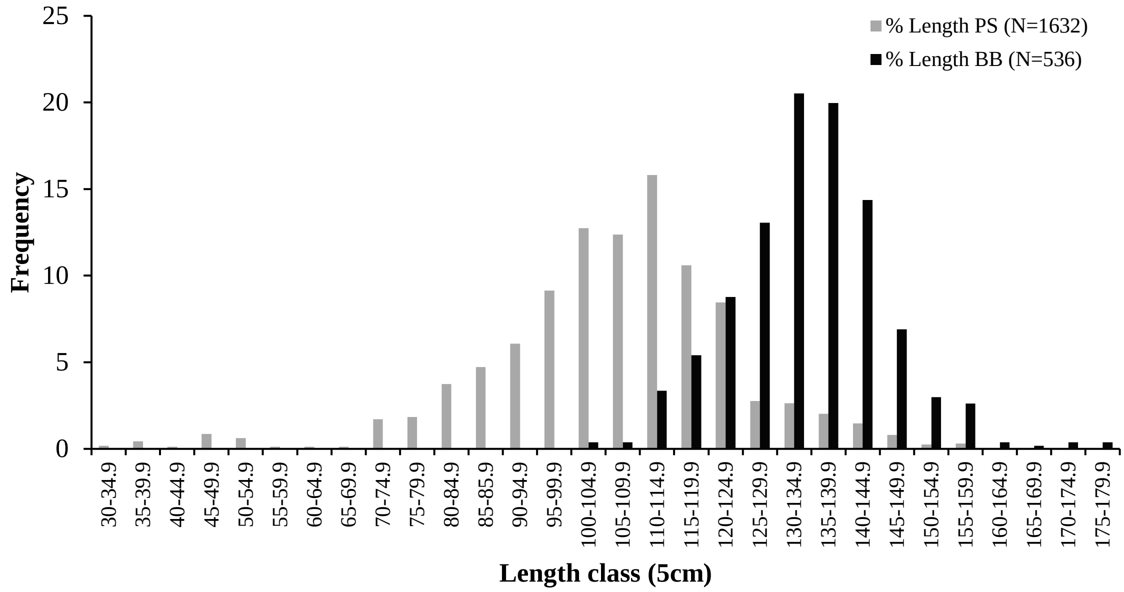


Figure 7. Length frequency distribution of wahoo specimens caught in artisanal bait boat of El Hierro BB (Canary Islands) and the East Central Atlantic by Spanish Purse seiner fleet (PS).

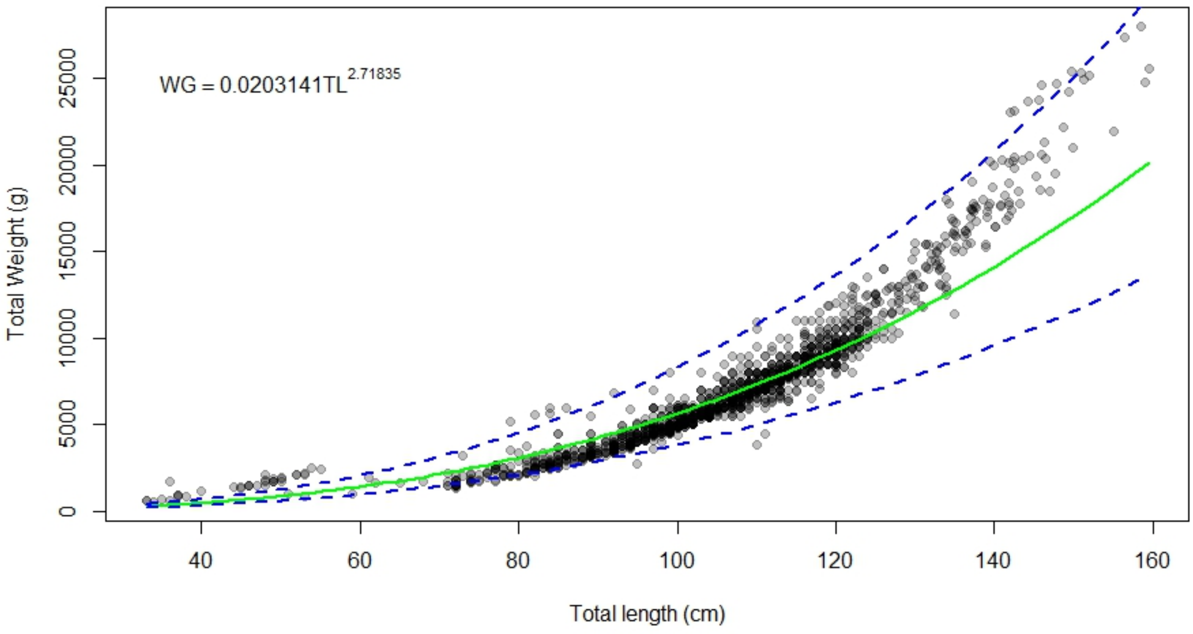


Figure 8. Relationship length-whole weight for wahoo from the East Central Atlantic, the best fix in green line and confidence interval for 95%.